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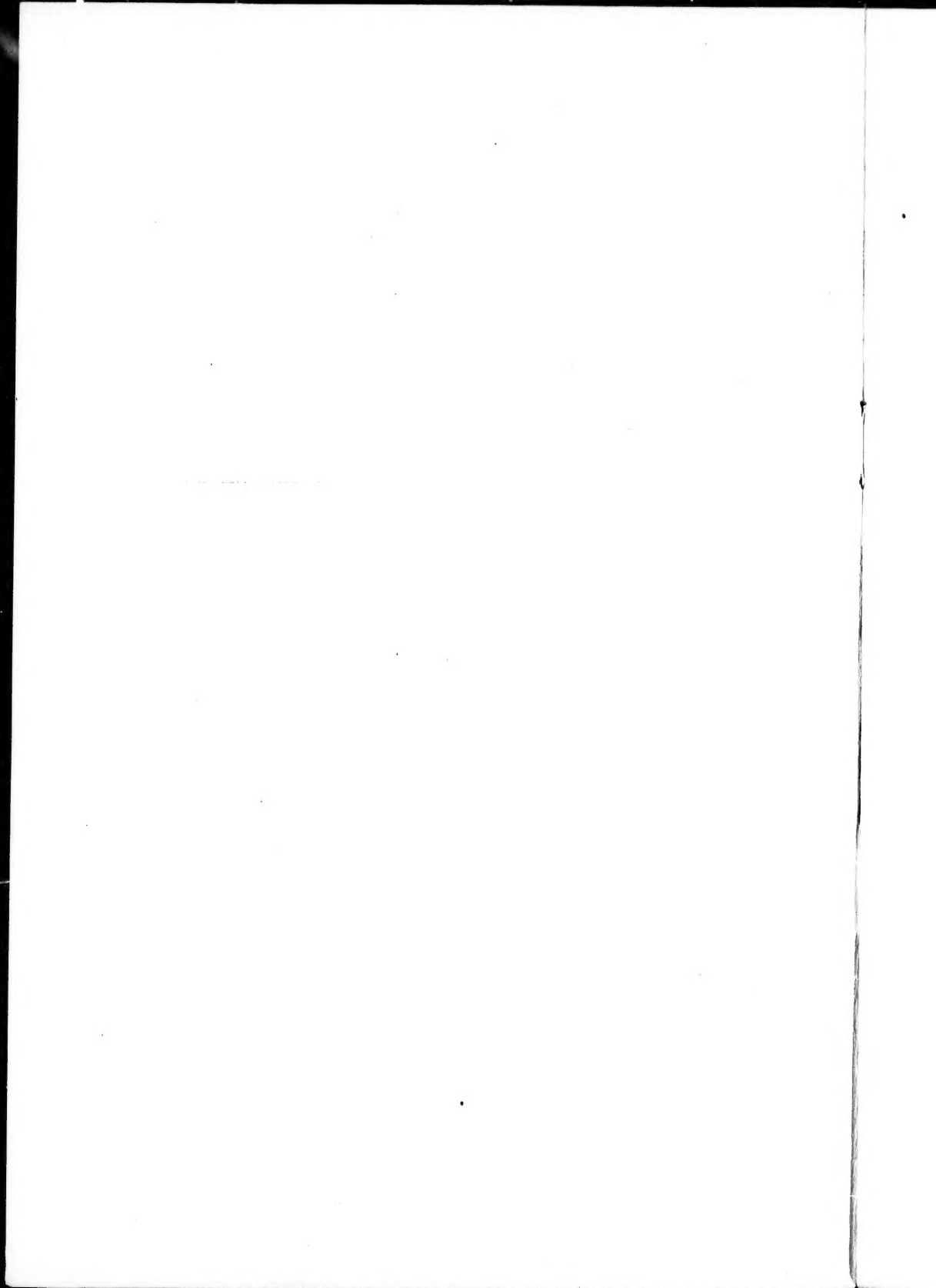
BY

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ELECTRICAL BURNS.*

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My attention has been directed to this subject by two cases of severe burns, from contact with a "live wire," which I had in my Wards at the General Hospital during the past summer. These burns differed so much in their behaviour from other burns of an apparently similar degree of severity, that I looked up the literature of the subject as carefully as I could, and thought that a communication on the subject might prove of interest to the members of this Society. Electricity is now in such general use that the general medical practitioner must be prepared to treat intelligently any accident, due to it, which may befall any of his patients ; and I was somewhat astonished to find very little on the subject in such surgical literature as I had access to.

The "Year Book" for 1899, directed my attention to an article on the subject of this paper, published in the Philadelphia Medical Journal, January 29th, 1898, by Dr. Sharpe, of St. Louis, Mo., in which the author, who was surgeon to several large Electrical Companies, gives an excellent summary of the chief clinical features of Electrical Burns. Dr. Sharpe's remarks coincide, in the main, with my own observations in the cases I shall cite, and therefore, with your permission I shall quote Dr. Sharpe's conclusions, adding, as I go along, any differences I may have noticed.

1. *As to appearance.*—"The burn is at first dried and crisp, (even charred in many cases), the site being excavated and bloodless, with a surrounding zone of pallor. Within 36 to 48 hours, this picture will completely change ; oozing will replace the dryness and the pallid zone will become hyperæmic." In other words, I would remark, all the symptoms of moist gangrene will set in, followed by rapid formation of slough with a peculiarly fetid odor. Much the same sort of picture, at first, as we are familiar with in severe frost-bites.

2. *Pain.*—"Is as a rule very moderate, in some cases practically absent ; from 24 to 48 hours after contact it is usually present."

From this view of Dr. Sharpe's I am forced to dissent. It may be true in very slight burns, as I have no experience of these, both of my cases having been severe ; but both my patients suffered very greatly, all through the prolonged period of sloughing, needing opiates constantly to enable them to get even a little rest.

* Read before the Montreal Medico-Chirurgical Society, Nov. 3, 1899.

3. *Shock*.—"Electric burns differ from other burns, in that the systematic shock is from the contact—the shock from the burn, *per se*, being nil." My experience differs here again. I found that in electrical burns, as in others, the shock was considerable, depending on the amount of tissue involved, and further, that the shock continued for a much longer period, due, no doubt, to the prolonged sloughing of adjacent tissues.

4. *Prognosis*.—"In regard to time, electric burns average $1\frac{1}{2}$ to 3 times as long in recovery as do other burns. In severe cases, even 5 times as long. Prognosis of result is as uncertain as time-prognosis; . . . usually, both mild and severe cases are tedious and prolonged." With these views I heartily agree. The tissue lost is in the prolonged sloughing, which no treatment serves to hasten—not even amputation—and one must wait patiently until healthy granulations replace the fetid sloughs before any prognosis as to time, or as to result, should be given; after that, as I shall show you, we may reduce the time very much by skin grafting.

5. *Subsequent manifestations*.—Dr. Sharpe says, "the rule of the electric burn, is, that it changes within 36 hours from contact, to a serum-saturated area, with disintegrating walls and floor, progressing to profuse purulent secretion, with continued tissue degeneration. This degeneration will frequently involve nerve, muscle, tendon, joint capsule, ligaments, articular surfaces, periosteum and bone itself; exuberant granulations springing up, the entire plain bathed in pus, completing a picture alike distressing to patient and surgeon." So far as I have been able to observe the sloughing affected mostly the muscles and blood-vessels. The bones, other than those actually charred, not being markedly affected, and I saw no evidence of osteo-myelitis higher up. The nerves, too, appeared acutely sensitive, but the great sloughing suggested some great interference with the trophic fibres to a considerable distance from the point of contact. As regards the blood-vessels, the walls appeared to be affected for a considerable distance up the limb; and during the period of sloughing, one must constantly guard against secondary hæmorrhage. This untoward accident is also favored by the fact, that the blood showed no tendency to clot in these burns; and this, I understood from Dr. Wyatt Johnston, is a well marked post-mortem feature of the blood of those who have been killed by electricity.

In one of my cases, while dressing the wound, an artery spurted very freely in a granulation at some distance up the limb from the point where I had amputated some weeks previously.

My experiences, then, would lead me to conclude, that the ascending degeneration following on severe burns by electricity, affects chiefly the

striped muscle tissue; and that the original area of injury gave one very little idea as to how far the process would ultimately extend.

And now *as to treatment*:—I quite agree with the author quoted when he says, "it is very unsatisfactory." I pursued the plan of keeping the parts immersed in a warm carbolic bath of 1-100 strength. Even then the disagreeable odor was most marked, and I know of no class of cases, except *crancrum oris*, so difficult to disinfect. The bath was carefully watched for any indication of hæmorrhage, as the necrotic process went on; an Esmarch was left at the head of the bed, with instructions to apply it at once, if bleeding began. I mention this because I had hæmorrhage in both cases, and, as the patients were both greatly reduced in strength by the sloughing, with its consequent fever and pain, I believe that the prompt application of the Esmarch by the attendant turned the scale in the patient's favor; and enabled both to withstand the shock of the subsequent amputations. Next, when forced to do so by secondary hæmorrhage, or by a well marked line of demarcation having formed between the necrotic and the apparently sound tissue, it is our duty to remove the sloughing tissue even if it means an amputation. And here I wish to emphasize this point, that the amputation should not be done as in ordinary cases of burn or injuries requiring operative interference. Ordinarily, if we form our flaps well above the line of demarcation, we may sew them up and expect primary union. But not so here; we must expect sloughing in the stump; not perhaps of the skin itself, but of the muscles even as high as their attachments. We should simply excise the necrosed portions along the line of demarcation, and then leave the wound open, to be dressed by moist antiseptic dressings. In both of my cases of amputation through the forearm, I did a simple circular amputation, made no attempt to form flaps, and the stump had to be left to granulate, and subsequently was skin-grafted. I am convinced from a former experience that any attempt to sew up the wound, in the ordinary way, would have resulted disastrously to the patient; as after the amputations whole muscles come away and large areas of skin above the point of amputation sloughed. There is altered nutrition—a local atrophy—due to the influence of electricity on the tissues, and one, therefore, cannot count upon the vitality of the flaps. Not uncommonly, owing to the retraction of the soft parts resulting from sloughing, it is necessary to resect the bone before skin-grafting.

The result of those excised where no skin-grafting was resorted to, was similar to that obtained in other largely denuded areas; and the skin-grafting gave good results.

There are several very interesting side issues arising from a study of these two cases, and I shall only refer to them briefly, in the hope that

some member who is better versed in the study of electricity than I am may throw some light on what is, to me, a still unsolved problem.

1. Why does the burn take place at the points of entrance and exit of the electrical fluid (if one may use the analogy of a bullet), and the intervening tissues—many of them vital—not be affected to any appreciable extent?

2. Why does the application of an electrical current, of say 600 volts, prove fatal in some instances, while in others, e. g. case II. above, a current of many times that strength simply inflicts severe burns, but does not produce any serious or prolonged direct vital effect? And why, again, in many of the fatal cases, should there be almost no mark, or other sign of burn, while in cases such as I have cited here, there should be such extensive burning as to necessitate amputation? These are questions which I am still studying, as they are of great interest, not only theoretically, but practically.

To this subject I hope at some future time to return, but at present I have nothing positive to offer, and moreover, I doubt if such information could be classed under the heading of Electrical Burns.

CASE I.—[Notes by Dr. R. M. Patterson, House-Surgeon, Montreal General Hospital.]

H. S., age 15. Patient was brought to the hospital June 22, 1899, and gave the following account of his injury:—

He had been astride a steel rod on the roof of his house and had reached up and grasped the main wire carrying current for the electric lighting of the streets. He thus short-circuited the current and got the full force of the discharge—2200 volts—then on the wire. He was unconscious for from three to five minutes until he could be moved from his perilous position.

Examination.—The patient is very pale, fine perspiration on the forehead, extremities cold, pulse small and rapid, pupils both semidilated. The symptoms are those of severe shock.

Nature of injuries.—(1) Right hand completely charred with all the soft parts shrivelled up and all the joints opened; the digits turned back in position of over-extension. From hand up to a point within one and a-half inches of the elbow joint, the burning varies from fourth to first degree. (2) Left hand has two deep, fourth degree burns, one on the thenar and other on the hypothenar eminence. (3) Whole of the penis and scrotum are œdematous and burnt in many places quite deeply (4th degree). The inner and anterior aspect of the left thigh in its upper third is also severely burnt. It will thus be seen that the most severe burn was at the point of entrance of the electrical fluid (the hand) and again very extensive but not quite so severe at the point of exit or neutralization.

Treatment.—Patient was given frequent hypodermics of morphine alternating at times with strichnine, and this had to be kept up for a very long time. He had to be frequently catheterized for retention, due doubtless to the mechanical blocking up of the meatus urinarius by the burning and swelling. The arm was immersed in one per cent. solution of warm carbolic lotion and fomentations of the same applied to the perineum. Later, this was changed to formalin, 1-1000, with a view if possible to lessen the extremely offensive odour of the sloughs. The formalin soon caused such pain that a solution of hydrargyrum perchloridum, 1-10,000, was substituted. The diet was liquid, as nutritious as possible, and food was given every two hours.

The areas surrounding the burns were soon covered with large moist bullæ and these were soon succeeded by a very offensive, moist gangrene, with formation of very extensive sloughs. There was also present a severe cystitis on the fifth day after admission. On the tenth day after admission there was a profuse hæmorrhage into the bath in which the injured right arm had been kept immersed. An Esmarch bandage checked this and the limb was removed from the bath, bandaged and elevated. A special nurse was detailed to watch for any recurrence. The pain was very great and patient was very weak and blanched. Amputation was decided on, and forthwith carried out. A simple circular amputation was performed one and one-half inches below the elbow, so as to save the insertion of the biceps. Some of the muscles left in the stump could be seen to be infiltrated, and these afterwards sloughed as high as their insertions to the internal and external condyles of the humerus. No effort was made to close the wound which was dressed with a one per cent. carbolic dressing. The whole stump was finally covered with healthy granulations and the patient finally had good use of his elbow joint. The temperature never rose above 101°F. at any time, and rarely above 100°F.

In the meantime the perineal wounds were progressing favourably, healthy granulations replacing the sloughs which had separated; the testicles were almost bare and a nipple like process with the urethral orifice at the summit was all there was to represent the penis. On August 7th, in the absence of Dr. Eider, skin-grafting of the granulating areas of the stump, the arm, and the perineum and thigh was performed by Dr. J. Anderson Springle, following Thiersch's method, and the result was in every way satisfactory, the patient being able to leave the hospital on August 23rd. He is now quite well, has no difficulty in urinating, and the stump of the arm gives good motion at the elbow to a false forearm and hand.

CASE II. [Notes by Dr. W. L. Barlow, House-Surgeon, Montreal General Hospital.]

T. V., aged 25, was brought to the Montreal General Hospital by the ambulance on August 30, 1899, suffering from severe electrical burns. The history of the accident is as follows :—

While walking down one of the passages in the power house of the Montreal Street Railway, the patient's foot slipped and in the attempt to save himself from falling he put out his right hand, which came in contact with a terminal from the main line at Chambly. Patient states that at the time the indicators registered 60 amperes at 10,000 volts. The shock he received rendered him unconscious for about two minutes, and when he recovered consciousness he was lying about six feet from the terminal. On attempting to get up he found that his right arm was powerless and that his fore-arm and right hand were in a position of extreme flexion, and were found so on admission to the hospital. Loss of power was also present in the lower extremities. When brought to the hospital, he was in a well-marked condition of shock.

The fingers of the right hand, as well as the hand itself, were charred, while from the level of the wrist joint to about half way up the fore-arm there was a purplish red discolouration. This became less marked as it reached the upper portion of the fore-arm and had an ill-defined irregular outline. On the inner surface of the right arm, about the level of the insertion of the deltoid, there was a deep burn through skin and subcutaneous tissue exposing the deep fascia. (See Fig. I.) The toes of the left foot were blanched and cold, while three inner toes of the right foot were in a similar condition. The dorsal surfaces of the feet were also involved, but here there was only an erythema, as of a burn of the first degree, save for about one inch above the metatarsal phalangeal articulations, where there was the same purplish-red discolouration as on the fore-arm of the left upper extremity. Scattered over these areas of discolouration, vesicles had already appeared, which later coalesced and formed large bullæ. (See Figs. II. and III.) There was marked swelling of the left fore-arm and of the feet.

Treatment and Course of the Case.

On admission, strichnine $\frac{1}{30}$ gr., and morphine $\frac{1}{8}$ gr. were given hypodermically. Half an ounce of whisky was given every three hours and the hand and arm immersed in a hot carbolie bath, 1-100, and the feet wrapped in hot carbolie fomentations, changed every two hours. There was retention of urine. During the first 24 hours the pain was very severe and morphine, gr. $\frac{1}{2}$, hypodermically, with also phenacetin gr. v, and caffeine gr. iiss, chloral hydrate, gr. xx, and potassium bromide, gr. xxx, were given at different times to secure rest.

On September 4th, a sharp hæmorrhage took place into the bath from the radial artery of the right arm. The sloughs were very fetid

in both the arm and feet, and it was seen that he would evidently lose his fore-arm and all the toes of both feet. As the bullæ burst or were punctured, deep sloughing areas were exposed. The sloughing was most marked where the discolouration had been most pronounced and had involved the muscles. There was never any definite line of demarcation.

On September 5th, six days after admission, his right fore-arm was amputated at the junction of the upper and middle thirds. As much tissue as possible was saved, the wound being left open for complete drainage and to allow all necrotic tissue to be removed at each subsequent dressing. As there was no definite line of demarcation and no guide as to the probable extent of sloughing, it was thought advisable to pay no regard to flaps, but after all the sloughs had separated and granulation taken place, to skin-graft the stumps.

The integument, superficial vessels (which were thrombosed), and most of the muscular part of the biceps just above the antecubital space, were destroyed, presenting a sloughing area which was thoroughly scraped and swabbed with carbolic, 1-40, and afterwards with normal saline. The sloughing area on the inner surface of the arm at the insertion of the deltoid was treated in the same way. The great, second and third toes of the right foot were amputated at the metatarsal phalangeal articulations and the heads of the corresponding metatarsal bones snapped off. All the toes of the left foot were amputated in the same way and about half of the metatarsal area exposed on the dorsum of the foot. Dressings of hot carbolic fomentations were ordered to be repeated every four hours, for 24 hours.

After a prolonged period of sloughing, affecting chiefly the muscles and associated with a tendency to secondary hæmorrhage in the stump of the arm, healthy granulations at last appeared. Skin-grafting of the stump of the arm was done by Dr. J. Alex. Hutchison, 36 days after the amputation or 42 days after admission. The skin-grafts of the arm have taken very well indeed and the right foot has healed by the usual method of granulation and cicatrization. The dorsum of the left foot, however, Dr. Hutchison tells me, will need to be grafted. The patient, at the time of writing, is well and hopes to be soon discharged from the hospital.



ELECTRICAL BURNS.

FIG. I.—T.V., Right Arm, 4th day after injury.



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FIG. II, T.V., Left Foot, 4th day after injury.



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FIG. III. T.V., Right Foot, 4th day after injury.